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Research report

Physical activity, exercise coping, and depression in a 10-year cohort study of depressed patients

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Abstract

Background: Epidemiological research examining the relationship between physical activity and depression has been conducted almost exclusively with community samples. We examined associations between physical activity, exercise coping, and depression in a sample of initially depressed patients, using four waves of data spanning 10 years.
Methods: A cohort (n=424) of depressed adults completed measures of physical activity, exercise coping, depression, and other demographic and psychosocial constructs at baseline, 1-year, 4-years, and 10-years, with a 90% wave-to-wave retention rate. Multilevel modeling was used to analyze individual depression trajectories.
Results: More physical activity was associated with less concurrent depression, even after controlling for gender, age, medical problems, and negative life events. Physical activity counteracted the effects of medical conditions and negative life events on depression. However, physical activity was not associated with subsequent depression. The findings for exercise coping were comparable.
Limitations: Measures of physical activity and exercise coping encompassed a limited set of activities and did not include information about duration or intensity.
Conclusion: Our results suggest that more physical activity is associated with reduced concurrent depression. In addition, it appears that physical activity may be especially helpful in the context of medical problems and major life stressors. Clinically, encouraging depressed patients to engage in physical activity is likely to have potential benefits with few obvious risks.
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Keywords: Physical activity; Exercise; Coping; Depression; Longitudinal research

1. Introduction

Epidemiological studies of community samples have shown that individuals who engage in more physical activity are less likely to be concurrently depressed (Farmer et al., 1988; Kritz-Silverstein et al., 2001; Strawbridge et al., 2002). For example, Camacho, Roberts, Lazarus, Kaplan, and Cohen (1991) found that, after adjusting for age, gender, and physical disability, individuals with low activity levels were at much greater risk for depression compared to a high-activity reference group (adjusted OR=4.22, 95% CI: 3.17,5.62). Similarly, Kritz-Silverstein, Barrett-Connor, and Corbeau (2001) found that more intensive and frequent activity was associated with lower scores on the

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Beck Depression Inventory (BDI). Although the mechanisms and causal direction underlying the link between physical activity and depression are unknown, numerous pathways have been hypothesized, such as increased serotonin and endorphins, associated increases in hardiness, reduced stress reactivity, and activity-related increases in control, mastery, and self-efficacy (Paluska and Schwenk, 2000).

Evidence for the protective effect of physical activity on subsequent depression has been mixed. At least four studies using community samples have failed to find a protective effect of physical activity for subsequent depression (Cooper-Patrick et al., 1997; Kritz-Silverstein et al., 2001; Lennox et al., 1990; Weyerer, 1992). For example, Kritz-Silverstein et al. (2001) found no association between baseline exercise and either BDI scores or changes at a 5-year follow-up. However, several studies have found long-term protective effects of physical activity (Camacho et al., 1991; Farmer et al., 1988; Paffenbarger et al., 1994; Strawbridge et al., 2002). For example, among non-depressed women, Farmer et al. (1988) found that more recreational physical activity at baseline independently predicted less depressive symptoms eight years later.

Several potential explanations exist for these inconsistencies. One issue is that researchers have used quite diverse measures of physical activity, exercise, and depression. For example, definitions of physical activity have ranged from gardening to participation in strenuous sports. Another issue is that prior longitudinal studies have typically examined of physical activity and depression at only two assessment periods. The hazards of estimating longitudinal relationship with only two waves of data have been elaborated elsewhere (Rogosa, 1988). Utilizing more than two waves of data yields greater precision and reliability in estimating longitudinal associations (Singer and Willett, 2003).

The present study addresses these issues, as well as other gaps in the epidemiological literature linking physical activity and depression. Our primary goal was to examine the nature and magnitude of the association between physical activity and depression in initially depressed patients. This relationship has been overlooked in the epidemiological literature, is of substantial clinical interest, and has implications for treatment and relapse-prevention. To date, virtually all of the epidemiological studies have used community-based (non-patient) samples and have excluded depressed individuals. Although these studies are informative about the potential protective effects of physical activity on the onset of depression, they do not address the potential therapeutic effects of physical activity for people who are already depressed. Therefore, we focused on patients who were depressed at baseline.

Second, previous studies have assessed the type and frequency of physical activities, but have not considered the personal meaning or function of the activities. If the mechanisms by which physical activity affects depression involve the personal meaning or motivation for activities, then the failure to consider these constructs may introduce noise (unreliability) into estimations of effects. For example, physical activity that is used to help cope with distress may be more closely associated with depression than physical activity motivated by social contact or attempts to lose weight. To begin to address this issue, we consider the influence of exercise as a strategy for coping with a recent stressful event on depression.

Third, we examine individual depression trajectories using mixed-effects regression models. This approach enables us to assess longitudinal effects across four waves of data. To address questions about the correlates of change in depression, growth-curve modeling provides a precise, reliable, powerful, and statistically accurate method (Rogosa, 1988; Rogosa and Willett, 1985; Singer and Willett, 2003; Willet, 1988).

Fourth, most prior studies have examined only the main effects of physical activity on depression. Although a few studies have considered the buffering effect of physical activity on the relationship between stress and depression or stress and anxiety (Carmack et al., 1999; LaPerriere et al., 1990), none have done so in depressed patients. Therefore, in addition focusing on the main effects of physical activity and depression, we examine buffering hypotheses captured in the following question: Does physical activity or exercise coping reduce the strength of associations between negative life events or health status and depression? Clinically, support for these hypotheses could inform prescriptions of physical activity as a buffer against the impact of negative life events on depression. We also checked the reverse causation hypothesis, that is, whether depression status predicts change in physical activity.

Our final goal was to provide evidence that might corroborate the results of recent randomized controlled trials (RCTs; e.g., Dunn et al., 2005) suggesting that interventions to increase physical activity are a feasible and effective strategy for treating mild to moderate depression. Congruence between findings from RCTs and observational studies should strengthen confidence in the results obtained from both types of studies. Evidence from naturalistic observational studies that supports the findings of RCTs suggests that results from RCTs may generalize beyond the selected individuals willing to participate in them.

2. Methods

2.1. Patient sample

This research is part of an ongoing longitudinal study of depression. The overall study is examining the factors than influence the naturalistic course of depression. Participants (n=424) were patients entering one of five facilities for the treatment of depression, including two community mental health centers, a health maintenance organization, a university hospital, and a Department of Veteran Affairs Medical Center. All patients were over 18 years old and met Research Diagnostic Criteria (RDC) for unipolar depression. Exclusion criteria included diagnosis with concurrent neurological, metabolic, manic, or substance use disorders.

2.2. Measures

At all four time points, participants completed the Health and Daily Living Form (HDL; Moos et al., 1992), a survey of social, psychological, and physical functioning.

2.2.1. Depression

All patients were diagnosed as clinically depressed at baseline using the RDC (Spitzer et al., 1978). An index of global depression severity was constructed using the ten criteria for major depressive disorder from the RDC plus eight additional criteria for minor depressive disorder. The Global Depression Index (GD) is the sum of 18 items rated on 5-point scales varying from zero (never) to 4 (often) in reference to the last month. The total score can range from 0 to 72, has Cronbach's alphas of .92 for both depressed and non-depressed samples (Moos et al., 1992), and is highly correlated (average r=.86) with the BDI.

2.2.2. Physical activity

The Physical Activity Index (PA) was obtained by summing four items (yes=1/no=0) asking patients whether or not they engaged in (a) swimming or tennis with friends, (b) or family, (c) long hikes or walks with friends (d) or family during the last month. The total score ranged from zero (no activity) to four (high activity). Exercise Coping (EC) was assessed with one item asking patients how often on a scale from 0 (never) to 3 (fairly often) they exercised more to cope with an important problem or stressful event they had faced in the previous year.

2.2.3. Stressors

Two indexes drawn from the HDL (Moos et al., 1992) assessing stressful life circumstances were used as covariates in the main effects analysis and again in tests of the buffering hypotheses. The presence of current medical conditions was assessed by a count of 14 common medical problems that might impact patients' ability or willingness to engage in physical activity, such as asthma, arthritis, diabetes, serious back trouble, and heart trouble. The number of negative life events in the previous three months was assessed by a count of "yes" responses to 15 items describing events such as divorce, laid off from job, legal problems, or death of a close friend.

2.2.4. Other covariates

Age in years and gender were assessed at baseline.

2.3. Analytic plan

The multilevel modeling strategy used here follows the approach outlined by Singer and Willett (2003). For each individual, we modeled a linear trajectory that yielded estimates of the individual's true initial depression status (intercept), the slope of the individual's depression trajectory (with lower numbers signifying more rapid recovery), and error, a measure of how well the linear model fit that person's data. As recommended when fitting linear models to symptom data that tends to decrease sharply initially and then more slowly thereafter (Gibbons et al., 1993), time was clocked in log (years+1) and an autoregressive covariance structure was used.

We then addressed three main questions for each predictor (physical activity and exercise coping): (a) Is the predictor concurrently associated with depression status? (b) Are baseline measures of the predictor associated with change in depression over time (slope)? (c) Does the predictor influence the strength-of-association between either medical problems or negative life events and depression? To test this buffering hypothesis, medical problems were used to predict global depression, yielding a strength-of-association statistic for each person. We then examined whether either physical activity or exercise coping was significantly associated with the strength of the association between medical problems and depression. The process was repeated for the association between negative life events and depression.

3. Results

The numbers of patients at the 1, 4, and 10-year follow-ups were 395, 370, and 313, respectively, roughly

a 90% wave-to-wave retention rate of surviving patients. One of the advantages of the multilevel modeling strategy is that data from all 424 patients could be included in the analysis. However, we checked whether those patients who provided data only at baseline differed in any systematic way from patients who provided data at two or more assessments and found no differences on any of predictors, covariates or outcomes. At intake, the sample was 54% female and 84% Caucasian, and had a mean (SD) age of 39.9 (14.1) years. In terms of education, 16% had less than a high school degree, 25.7% had a high school degree, 35.8% attended some college, 9.9% had a college degree, and 12.5% had completed 5 or more years of higher education. For more details on patient characteristics, see Billings, Cronkite, and Moos (1983) and Billings and Moos (1984).

Means and standard deviations of physical activity, exercise coping, and global depression are presented in Table 1. To provide a basis of comparison for subsequent analyses, we modeled individual depression trajectories without between-person predictors (see Model A in Table 2). The average (SE) initial depression predicted score was 43.40 (.72) and the average (SE) slope was −9.31 (.50). The correlation of initial depression status and slope was $r=-0.34$ ($p<.05$), indicating that individuals with higher predicted baseline depression scores tended to have steeper recovery slopes.

3.1. Physical activity as a predictor of concurrent depression

We added physical activity, centered at its mean, as a time-varying predictor to Model A. By allowing physical activity to vary within person across time, we assessed its concurrent association with global depression at all four time points simultaneously. This approach also allowed us to judge the extent to which there were variations in the association over time. Controlling for physical activity, the average (SE) initial depression score (intercept) was 45.32 (.92) (see Model B in Table 2). In this context, controlling for physical activity estimates the initial depression status at the mean value of physical activity. The effect of physical activity on global depression was −2.24 (SE=.64, $p<.001$), indicating that higher levels of physical activity were concurrently associated with lower levels of global depression. For example, at any time point, one increment of physical activity was associated with a 2.24-point drop in depression. The variation in the association across time was not significant, a result that was confirmed by the correlations between physical activity and concurrent depression at the four assessments ($r=-.14$, −.18, −.20, and −.10, respectively).

Covariates were added to Model B to examine if the relationship between physical activity and global depression could be explained by gender, age, medical conditions, or negative life events during the previous three months (not shown in Table 2). Age and gender were treated as time-invariant and the other two covariates were treated as time-variant. Gender and age were not significant predictors of global depression status or slope. More medical conditions significantly

Table 2
Effect of physical activity and exercise coping on global depression (GD) over 10 years

	Model A	Model B	Model C
	No predictors	Physical activity	Exercise coping
GD initial status (SE)	43.40*** (.72)	45.32*** (.92)	44.17*** (.87)
Effect of predictor on GD status (SE)		−2.24*** (.64)	−1.23* (.59)
GD slope (SE)	−9.31*** (.50)	−9.70*** (.70)	−9.70*** (.66)
Effect of predictor on GD slope (SE)		0.59 (.51)	0.63 (.46)
Model deviance	12,116	11,661	11,583
Δ Deviance from Model A		455***	533***

*$p<.05$, **$p<.01$, ***$p<.001$.
Model deviance=−2 restricted log likelihood.

Table 1
Descriptive statistics of physical activity, exercise coping, and global depression at 4 waves

	Mean (SD)			
	Intake	1-year	4-years	10-years
Physical activity	0.89 (0.98)	1.00 (1.01)	0.95 (1.02)	1.03 (1.01)
Exercise coping	0.82 (1.09)	0.85 (1.05)	0.90 (1.11)	0.89 (1.11)
Global depression	43.95 (14.83)	32.66 (15.97)	29.93 (15.65)	27.31 (14.31)

predicted higher levels of global depression ($t=4.74$, $p<.001$) but did not predict depression slope. Negative life events in the last three months predicted more global depressive symptoms ($t=3.93$, $p<.001$), but did not predict slope. None of these covariates reduced the concurrent association between physical activity and global depression ($t=-3.32$, $p<.001$).

3.2. Baseline physical activity as a predictor of depression slope

As a time-varying predictor, physical activity did not predict depression slope. To focus on the long-term effect of physical activity at baseline, we constructed a model including physical activity as a time-invariant predictor, fixed at baseline values. Baseline physical activity did not predict change in depressive symptoms.

3.3. Physical activity as a buffer

We tested the hypothesis that physical activity would reduce the strength of the association between medical conditions and global depression. Each medical condition increased global depression by 3.27 points ($p<.001$), but every increment of physical activity reduced this amount by .90 points ($p<.001$). For example, a person with two medical conditions who was very active (PA=4) would be expected to have a global depression score considerably less than a person with two medical conditions who was sedentary.

Similarly, we tested the hypothesis that physical activity would reduce the strength of association between negative life events and global depression. Each negative life event was associated with a 3.90-point increase in depression ($p<.001$), but each increment in physical activity was associated with a decline in this amount by .89 points ($p=.002$). For example, a person who had experienced one negative life event and who was very active (PA=4) would be expected to have approximately the same global depression score as a sedentary person with no negative life events. In other words, for the active person, physical activity counteracts almost all the effects of a recent negative event on depression.

3.4. Exercise coping as a predictor of concurrent depression

We added exercise coping, centered at its mean, as a time-varying predictor to Model A (see Model C in Table 2). By allowing exercise coping to vary within person across time, we assessed its concurrent association with global depression at all four time points simultaneously. Controlling for exercise coping, the average (SE) predicted initial depression score (intercept), for in this model was 44.17 (.87). In this context, controlling for exercise coping meant we were estimating the initial depression status at the mean value of exercise coping. The effect of exercise coping on global depression was −1.23 (SE=.59, $p<.05$), indicating that higher levels of exercise coping were concurrently associated with lower levels of global depression. At any time point, one increment of exercise coping was associated with a 1.23-point drop in depression. The variation in the association across time was not significant, a result that was confirmed by the correlations between exercise coping and concurrent depression at the four assessments ($r=-.12$, $-.11$, $-.01$, and $-.09$, respectively).

Covariates were added to Model C to examine if the relationship between exercise coping and global depression could be explained by demographic variables (e.g., gender, age), medical conditions, or negative life events during the previous three months. In the model with all covariates, age and gender were not significant predictors of global depression status or slope. More medical conditions significantly predicted higher levels of depression ($t=6.08$, $p<.001$) but did not predict depression slope. The occurrence of negative life events in the last three months independently predicted global depression status ($t=4.33$, $p<.001$), but not slope. The inclusion of the covariates did not reduce the significance of exercise coping in the model ($t=-2.62$, $p<.009$).

3.5. Baseline exercise coping as a predictor of depression slope

In a model containing exercise coping as a time-invariant predictor, fixed at baseline values, exercise coping did not predict changes in depressive symptoms.

3.6. Exercise coping as a buffer

We tested the hypothesis that exercise coping would reduce the strength of the association between medical conditions and global depression. Each medical condition increased global depression scores by 3.18 points ($p<.001$), but every increment of exercise coping reduced this amount by .67 points ($p=.003$). Similarly, we tested the hypothesis that exercise coping would influence the strength of the association between negative life events and global depression. Each negative life event during increased global depression scores by 3.45 points ($p<.001$), but every increment of

exercise coping reduced this amount by .66 points ($p=.012$).

3.7. Independence of physical activity and exercise coping

The Pearson correlation between physical activity and exercise coping was statistically significant, but modest ($r=0.22$). Because there could be a common factor underlying the observed relationships with depression, we examined whether physical activity and exercise coping were tapping separate constructs with respect to the prediction of depression. We fit a model in which physical activity and exercise coping simultaneously predicted global depression. The associations between physical activity and global depression remained unchanged with exercise coping in the model ($t=-4.45$, $p<.001$), and exercise coping was still marginally significant ($t=-1.92$, $p=.055$). These findings suggest that the indexes of physical activity and exercise coping are tapping distinct but related constructs.

3.8. Reverse causation

We estimated two models in which baseline depression predicted physical activity and exercise coping trajectories. There was no evidence that baseline depression influenced the trajectories of either physical activity or exercise coping.

4. Discussion

In this sample of initially depressed patients, higher physical activity was associated with less concurrent depression at 4 assessments spanning 10 years. The cross-sectional association between physical activity and depression could not be explained by age, medical problems, or the presence of negative life events in the previous 3 months. Higher physical activity also counteracted the effects of medical conditions and negative life events on depression. However, although higher levels of physical activity were associated with less concurrent depression, they did not predict subsequent depression. These results are consistent with the evidence from recent RCTs demonstrating the efficacy of interventions that increase physical activity for the treatment of mild to moderate depression (e.g., Dunn et al., 2005).

More reliance on exercise coping was also associated with less concurrent depression, but not with changes in depression. More reliance on exercise coping also buffered the effects of medical conditions and negative life events on depression. Exercise coping appears to be a similar but somewhat weaker buffer than physical activity in the relationships between negative life events, medical conditions, and global depression. When the effects of both physical activity and exercise coping were examined together, the findings indicated that these variables represent essentially separate constructs, each of which is useful in understanding concurrent depression status.

It is important to note several limitations of this study. First, our measures of physical activity and exercise coping reflect only a small portion of potential physical activities and do not capture information about frequency, duration, or intensity of such activities. Presumably, if we had more comprehensive and precise measures, the observed effects may have been stronger and other relationships may have emerged. Also, if there were more frequent assessments over shorter intervals, we might have observed a prospective effect of physical activity on depression.

Our results support the idea that physical activity may help to reduce concurrent depression, yet clearly the causal link could be reversed. A positive feedback loop, in which less depression enables more physical activity, which then further reduces depression, is a plausible model that could be tested with more frequent assessments.

Our results suggest that physical activity may be especially helpful in the context of medical problems and major life stressors. Motivating depressed individuals who have medical problems or are experiencing major life stressors to be more physically active may be difficult. However, research suggests that it is possible and worthwhile. For example, several studies have shown the efficacy of interventions that promote physical activity in patients with medical problems that are highly comorbid with depression, such as rheumatoid arthritis (e.g., Westby et al., 2000) and coronary heart disease (e.g., Sniehotta et al., 2005). Moreover, there are accessible resources for clinicians who want to learn how to enhance motivation and activate behavior to increase physical activity in specific populations (e.g., Karner et al., 2005; Westby, 2001).

It is clinically important to understanding the nature and magnitude of associations between physical activity and depression. Empirical support should exist for behavioral prescriptions of increased activity for depressed patients in treatment. In this regard, our findings indicate that physical activity may have primarily concurrent effects on reducing depression. Clinically, encouraging depressed patients to increase and maintain physical

activities with friends or family appears to have immediate benefits on depression with few obvious risks.

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